instance, chromium and nickel), and two groups led by Verdaguer⁸ and Girolami⁹, respectively, are currently involved in a systematic investigation of these compounds. The general formula of the bimetallic Prussian-blue-like phases is $A_k[B(CN)_6]_l \cdot nH_2O$ where A is a high-spin and B a low-spin ion. (The ground state of a transition metal ion results from a competition between Hund's rule, which favours the high-spin state, and electron pairing, which favours the low-spin state. Usually, Hund's rule takes over and the ion has a high spin. In the hexacyanometallates, on the other hand, the electron pairing energy is exceptionally strong, and the ion has a low spin.) For $k = l$, the basic (idealized) structure is face-centred cubic with A–N–C–B linear linkages along three perpendicular directions, as shown in the box.

These compounds may be three-dimensional ferromagnets, antiferromagnets of ferrimagnets, depending on the nature of the A–B interaction. In ferromagnets, the two spin sublattices couple so that all spins are parallel. For both antiferro- and ferrimagnets, the two spin sublattices A and B couple in an antiparallel way. Antiferromagnetism corresponds to strict compensation of these sublattices, and ferrimagnetism to incomplete compensation so that there is a non-zero resulting spin. One of the very appealing aspects of the magnetic Prussian-blue-like phases is that these materials are excellent candidates on which to test theoretical models describing the magnetic interaction, in particular as far as symmetry rules are concerned.

In theory³, if the unpaired electrons from A occupy a set of singly occupied orbitals a_μ , and those from B occupy orbitals b_ν , the overall interaction between A and B arises from a sum of contributions involving pairs of these orbitals. When a_μ and b_ν have the same symmetry, the contribution is antiferromagnetic; configurations in which neighbouring spins are alternately up and down are favoured. When the orbitals have different symmetry, the contribution is ferromagnetic; it favours the up-up spin structure. Finally, when there are both antiferro- and ferromagnetic contributions, the former dominate, and the overall interaction is antiferromagnetic. Just how this applies to the Prussian-blue-like phases, and how it affects their critical temperatures, can be seen in the accompanying box.

So far, all known examples of Prussian-blue-like phases strictly obey these predictions. In the particular case of the compound reported by Verdaguer and co-workers², containing V(II), V(III) and Cr(III) sites for which all the magnetic orbitals have the same symmetry, the V(II)–Cr(III) and V(III)–Cr(III) interactions are strongly antiferromagnetic, and

the compound behaves as a ferrimagnet with a high critical temperature.

Of course, a magnet is not characterized just by its critical temperature; its saturation magnetization and its coercivity are also important. In particular, it is the coercivity defined by the width of the magnetic hysteresis loop that confers a memory effect on ferri- or ferromagnetic materials. At least 100 Oe would be needed for $V[Cr(CN)_6]_{0.86} \cdot 2H_2O$ to be useful in recording media. In the present case, the saturation magnetization is limited to 0.15 Bohr magnetons, owing to the weak value of the resulting spin per repeat unit. The coercivity is also weak; at 10 K, the value of the coercive field is only 10 Oe. Perhaps the use of more anisotropic spin carriers, which would prevent the magnetic domains from rotating freely as the field is applied, would result in an increased coercivity.

Strictly speaking, the phase that has been synthesized by Verdaguer and co-workers, $V[Cr(CN)_6]_{0.86} \cdot 2.8H_2O$, is not a molecular compound, but rather an amorphous and non-stoichiometric extended solid. However, this room-temperature magnet is prepared from the molecular precursor $[Cr(CN)_6]^{3+}$, and the synthesis of such a material may be considered as a cornerstone in the field of molecular magnetism. This is not the first room-temperature magnet to be synthesized from molecular precursors — a few years ago, there was a report¹⁰ of a compound of that kind, of formula $V(TCNE)_2$ — but the new compound is in many respects better characterized. Remarkably, it was obtained in a rational way, rather than as the result of serendipity, and all its magnetic characteristics (T_c , saturation magnetization, coercivity) are in line with the theoretical models developed in molecular magnetism. $V[Cr(CN)_6]_{0.86} \cdot 2.8H_2O$ is an interesting material in its own right, and an excellent example on which to learn (or to teach) the basic concepts of molecular magnetism. □

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Animal vegetables

ANIMAL rights campaigners complain ever more vociferously about the cruelties of modern agribusiness. They have a point. Hens in cages, pigs in sweatboxes and calves in crates can be raised very cheaply, but their lives are miserably restricted. There must be a better way.

Daedalus once proposed to put such creatures under permanent anaesthesia. This would pose many tricky problems, and might contaminate their meat. He now reflects that consciousness is the highest and most volatile of brain functions anyway. It can be abolished not only by drugs, but by oxygen deprivation or even by simple impact. The effect is usually brief, but can be permanent. A head injury sometimes leaves its victim alive but in an irreversible coma. His conscious brain centres are destroyed, while the lower centres that control his heart and lungs are untouched.

This tragedy for a man, says Daedalus, could be merciful release for a farm animal. An operation like prefrontal lobotomy but a bit further back, or partial asphyxiation with nitrogen, or even a well-judged bang on the head, could end the conscious life of a sheep or cow. It would be reduced to a comatose 'animal vegetable'. Unable to eat or drink, it would die in a few days. By itself, this simple treatment would be ideal for animals destined for slaughter in a distant country. They could be transported as passive animal vegetables, avoiding the usual miseries of such a long and comfortless journey.

An animal vegetable might, however, be kept alive indefinitely. A hen, for example, has many vital reflexes controlled by its spinal cord. It can even run after its head has been cut off. A well-designed brain operation could put it into a permanent coma, while leaving untouched its reflex ability to eat (or at least to swallow grain or drink water placed in its beak) and to lay eggs. Such hens could pass their whole battery lives in merciful oblivion. Passive and inert, they would not attack each other and would need no caging: the battery could be simpler and more profitable.

The same principle should apply to sweatbox pigs, crated calves and geese for *pâté de fois gras*. Once the proper neurosurgery had been worked out, all these creatures could be swiftly released from their miseries, leaving their breathing bodies to grow and develop for human benefit. Packed in racks, their food supplied and their wastes removed by machinery, the zomboid creatures would lift agribusiness to its ultimate peak of efficiency. And the industry could boldly claim that none of its charges suffer in the least.

David Jones